Climate Change Summary, George Washington Carver National Monument, Missouri

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Climate Trends for the Area within Park Boundaries

- While average annual temperatures have increased across most of the world, the southeastern U.S. is an anomaly due to El Niño and other factors (Portmann et al. 2009). Average annual temperature in the park decreased in the period 1950-2010, but the rate was not statistically significant (Table 1, Figure 2).

- Average total precipitation increased at a statistically significant rate in the period 1950-2010 (Table 1, Figure 2).

- If the world does not reduce emissions from power plants, cars, and deforestation by 40-70%, models project substantial warming and increases in precipitation (Table 1, Figure 3).

- Under the highest emissions scenario, models project 20-25 more days per year with a maximum temperature >35ºC (95ºF.) by 2100 and an increase in 20-year storms (a storm with more precipitation than any other storm in 20 years) to once every 6-10 years (Walsh et al. 2014).

Published Historical Impact in the Region

- Analyses of Audubon Christmas Bird Count data across the United States, including counts in Missouri, detected a northward shift of winter ranges of a set of 254 bird species at an average rate of 0.5 ± 0.3 km per year from 1975 to 2004, attributable to human climate change and not other factors (La Sorte and Thompson 2007).

Published Future Vulnerabilities in the Region

- Projected changes in rainfall timing and amount, potential evapotranspiration, and other factors may increase flooding and alter river and stream hydrology (Pryor et al. 2014).

- Under high emissions, the region could become even more favorable to the growth of the invasive plants kudzu (*Pueraria lobata*) (Bradley et al. 2010) and Japanese honeysuckle (Wang et al. 2012).

- Under the highest emissions scenario, climate change could shift the ranges of numerous tree species northward, reducing potential densities of white oak (*Quercus alba*) and American elm (*Ulmus americana*) (Iverson et al. 2008).

- Under high emissions, wildfire frequencies could increase up to 25% by 2100 (Moritz et al. 2012).

Table 1. Historical rates of change per century and projected future changes in annual average temperature and annual total precipitation (data Daly et al. 2008, IPCC 2013; analysis Wang et al. in preparation). The table gives the historical rate of change per century calculated from data for the period 1950-2010. Because a rate of change per century is given, the absolute change for the 1950-2010 period will be approximately 60% of that rate. The table gives central values for the park as a whole. Figures 1-3 show the uncertainties.

	1950-2010	2000-2050	2000-2100
Historical			
temperature	-0.9ºC/century (-1.6ºF./century)		
precipitation	+35%/century		
Projected (compared to 1971-2000)			
Low emissions (IPCC RCP 4.5)			
temperature		+2.2ºC (+4ºF.)	+2.9ºC (+5.2ºF.)
precipitation		+3%	+3%
High emissions (IPCC RCP 6.0)			
temperature		+1.9ºC (+3.4ºF.)	+3.3ºC (+5.9ºF.)
precipitation		+1	+4%
Highest emissions (IPCC RCP 8.5)			
temperature		+2.9ºC (+5.2ºF.)	+5.1ºC (+9.2ºF.)
precipitation		+5%	+5%

Figure 1. Historical annual average temperature for the area within park boundaries. Note that the U.S. weather station network was more stable for the period starting 1950 than for the period starting 1895. (Data: National Oceanic and Atmospheric Administration, Daly et al. 2008. Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).

Historical Mean Annual Temperature
George Washington Carver National Monument

1895-2010: 14.1 ± 0.7°C
1950-2010: 13.9 ± 0.7°C

Average annual
Five-year running average
Linear trend = -0.9°C century^{-1} (p = 0.1352)

Data: Daly et al. 2008.
Analysis: F. Wang, P. Gonzalez, M. Notaro, D. Vimont, J. W. Williams. in preparation. IPCC AR5 climate projections and exposure assessments for the US National Park System.

Figure 2. Historical annual total precipitation for the area within park boundaries. Note that the U.S. weather station network was more stable for the period starting 1950 than for the period starting 1895. (Data: National Oceanic and Atmospheric Administration, Daly et al. 2008. Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).
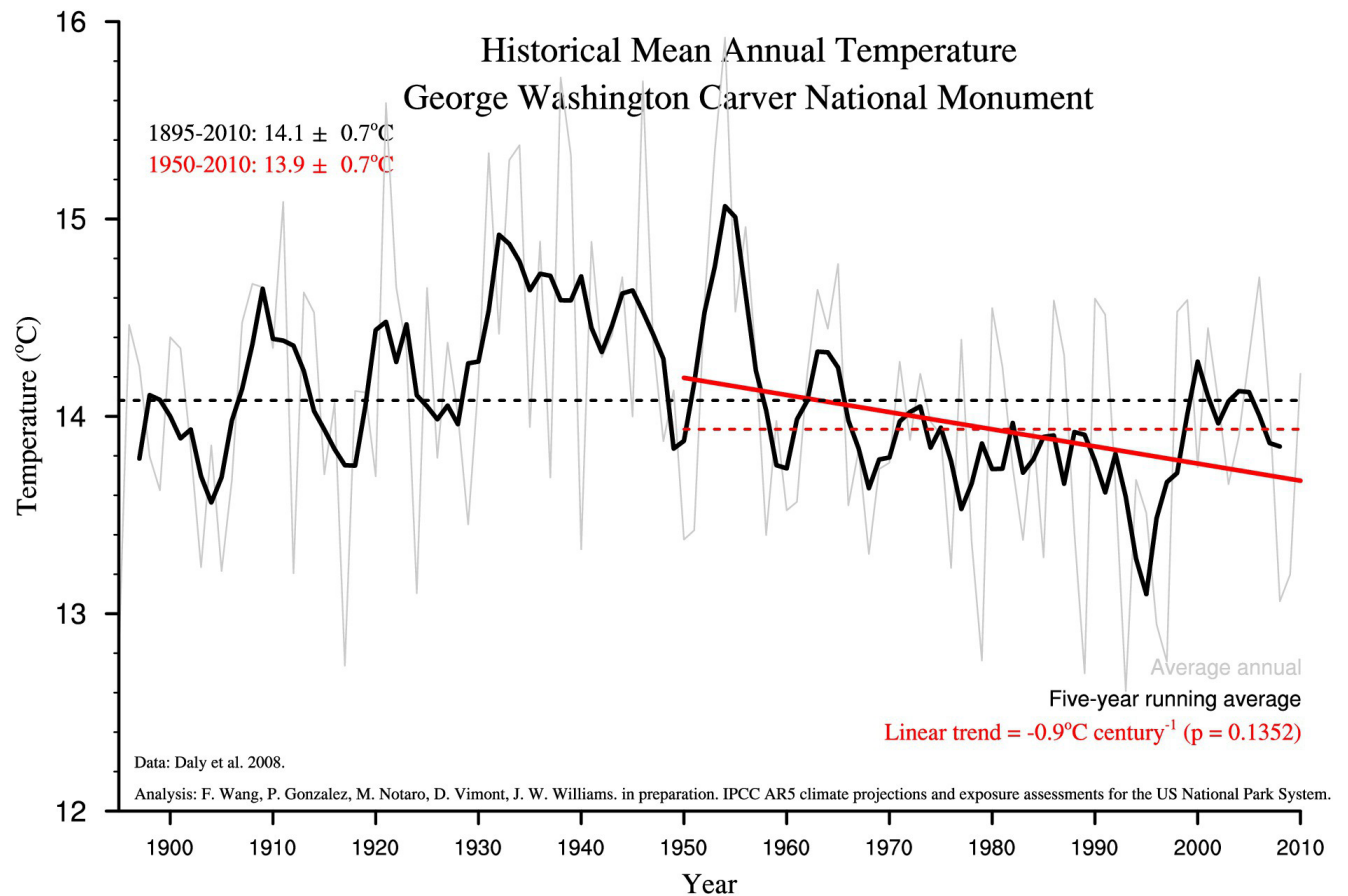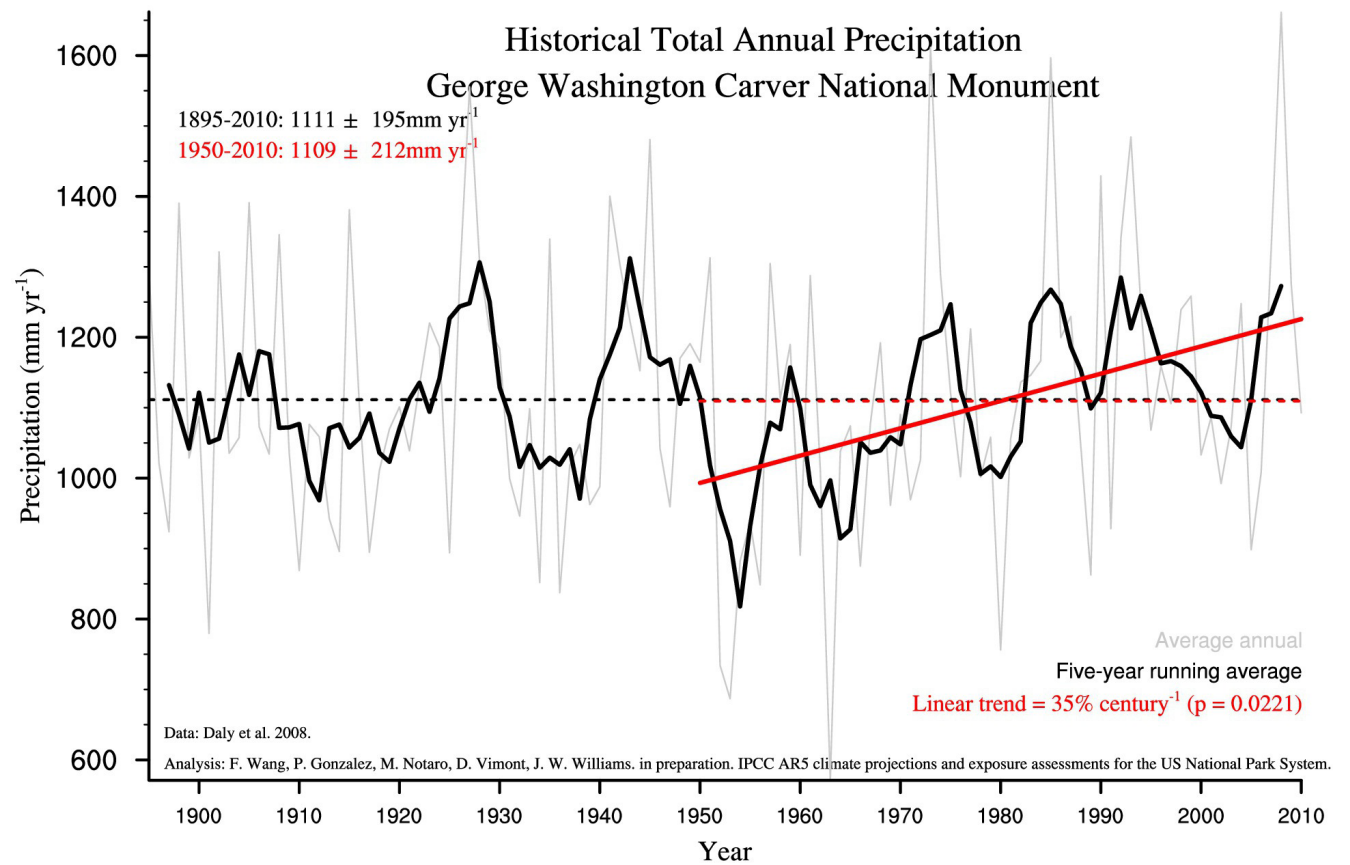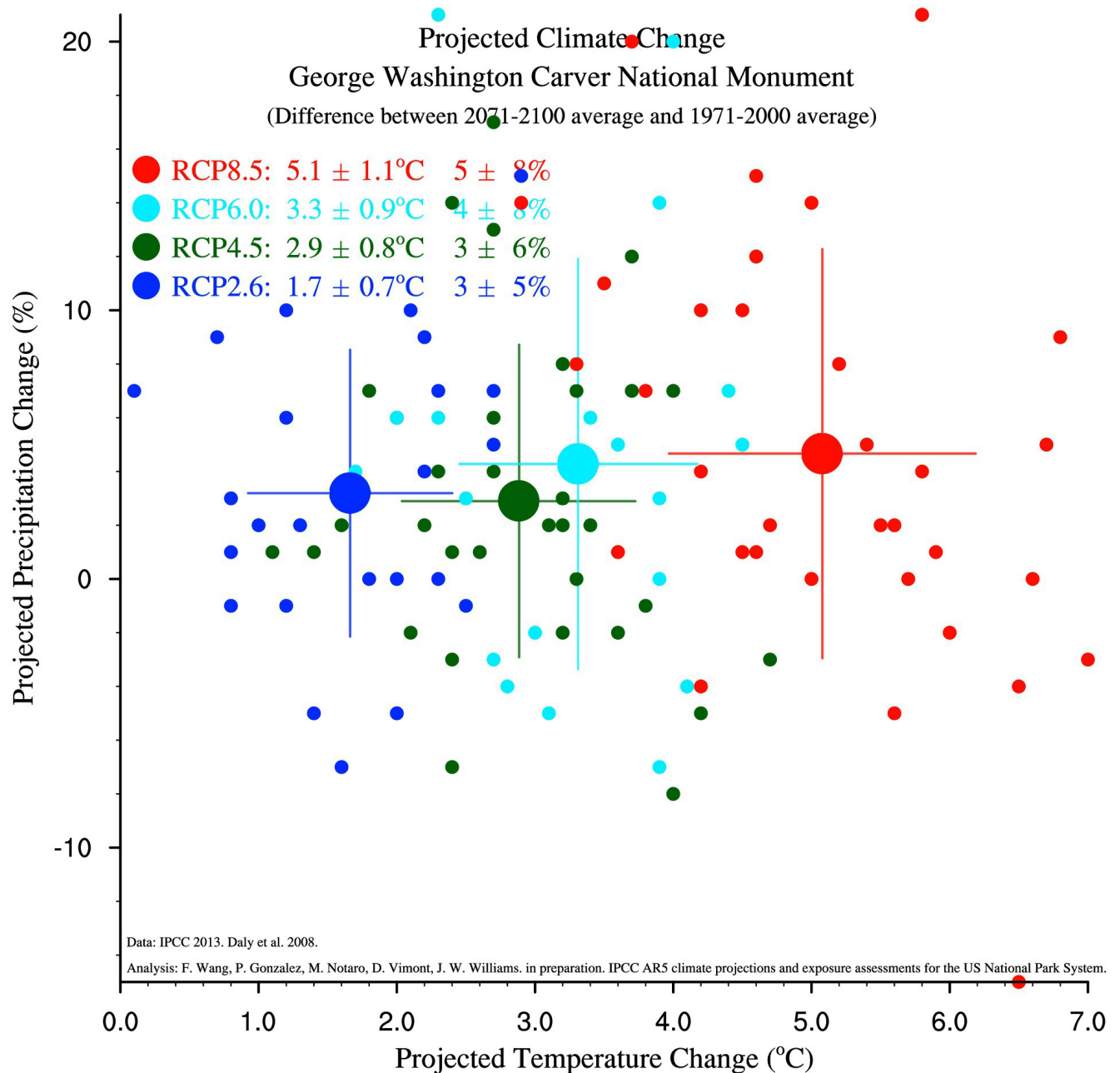

Historical Total Annual Precipitation
George Washington Carver National Monument

1895-2010: 1111 ± 195mm yr^{-1}
1950-2010: 1109 ± 212mm yr^{-1}

Average annual
Five-year running average
Linear trend = 35% century^{-1} (p = 0.0221)

Data: Daly et al. 2008.
Analysis: F. Wang, P. Gonzalez, M. Notaro, D. Vimont, J. W. Williams. in preparation. IPCC AR5 climate projections and exposure assessments for the US National Park System.

Figure 3. Projections of future climate for the area within park boundaries. Each small dot is the output of a single climate model. The large color dots are the average values for the four IPCC emissions scenarios. The lines are the standard deviations of each average value. (Data: IPCC 2013, Daly et al. 2008; Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).

Projected Climate Change
George Washington Carver National Monument
(Difference between 2071-2100 average and 1971-2000 average)

RCP8.5: 5.1 ± 1.1°C   5 ± 8%
RCP6.0: 3.3 ± 0.9°C   4 ± 8%
RCP4.5: 2.9 ± 0.8°C   3 ± 6%
RCP2.6: 1.7 ± 0.7°C   3 ± 5%

Data: IPCC 2013. Daly et al. 2008.
Analysis: F. Wang, P. Gonzalez, M. Notaro, D. Vimont, J. W. Williams. in preparation. IPCC AR5 climate projections and exposure assessments for the US National Park System.

References

Bradley, B.A., D.S. Wilcove, and M. Oppenheimer. 2010. Climate change increases risk of plant invasion in the Eastern United States. Biological Invasions 12: 1855-1872.

Daly, C., M. Halbleib, J.I. Smith, W.P. Gibson, M.K. Doggett, G.H. Taylor, J. Curtis, and P.P. Pasteris. 2008. Physiographically sensitive mapping of climatological temperature and precipitation across the conterminous United States. International Journal of Climatology 28: 2031-2064.

Intergovernmental Panel on Climate Change (IPCC). 2013. Climate Change 2013: The Physical Science Basis. Cambridge University Press, Cambridge, UK.

Iverson, L.R., A.M. Prasad, S.N. Matthews, and M. Peters. 2008. Estimating potential habitat for 134 eastern US tree species under six climate scenarios. Forest Ecology and Management 254: 390-406.

La Sorte, F.A. and F.R. Thompson. 2007. Poleward shifts in winter ranges of North American birds. Ecology 88: 1803-1812.

Moritz, M.A., M.A. Parisien, E. Batllori, M.A. Krawchuk, J. Van Dorn, D.J. Ganz, and K. Hayhoe. 2012. Climate change and disruptions to global fire activity. Ecosphere 3: art49. doi:10.1890/ES11-00345.1.

Pryor, S.C., D. Scavia, C. Downer, M. Gaden, L. Iverson, R. Nordstrom, J. Patz, and G.P. Robertson. 2014. Midwest. In Melillo, J.M., T.C. Richmond, and G.W. Yohe (Eds.) Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, Washington, DC.

Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, and J. Willis. 2014. Our changing climate. In Melillo, J.M., T.C. Richmond, and G. W. Yohe (Eds.) Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, Washington, DC.

Wang, F., P. Gonzalez, M. Notaro, D. Vimont, and J.W. Williams. in preparation. Significant historical and projected climate change in U.S. national parks.

Wang, H.H., C.L. Wonkka, W.E. Grant, and W.E. Rogers. 2012. Potential range expansion of Japanese honeysuckle (Lonicera japonica Thunb.) in southern U.S. forestlands. Forests 3: 573-590.